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Virtual control room helps nuclear operators, industry

IDAHO FALLS — Modernizing nuclear power plants to help extend their operating lifetimes is no small task. But the endeavor offers an opportunity to improve control-room design and layout.

The Department of Energy's new Human System Simulation Laboratory (HSSL) at Idaho National Laboratory is a full-scale virtual nuclear control room that can test the safety and reliability of proposed technology replacements before they are implemented in commercial nuclear control rooms. The facility is now helping Duke Energy embark on an upgrade project for several of its nuclear plant control rooms.

This one-of-a-kind control room simulator is specifically designed to facilitate digital renovation of existing plants, which predominantly use analog systems. The INL lab also enables scientists to improve control-room designs by studying human interactions with the instruments and responses to alarms.

"The goal is to provide industry with a capability to understand and test how proposed changes to existing instrumentation and control systems will affect their plants," said Richard Reister, manager of the Department of Energy's Light Water Reactor Sustainability (LWRS) Program in the Office of Nuclear Energy. "This will allow better design and digital upgrades with less risk of potential unforeseen problems."

Development of the virtual control room technology was initially funded with Laboratory Directed Research & Development funding. After completion of the LDRD project, the DOE LWRS Program provided funding to continue development of this capability.

The project began in 2010 to support updating of control-room alarm systems. However, researchers quickly realized that full control-room modernization was necessary to achieve the highest safety goals. The HSSL lab can now extensively evaluate operator performance and safety risks of a new control-room interface before it is installed in an active plant.

INL's control-room simulator is a hybrid facility that mimics both digital and analog systems, which typically support physical controls such as valves, gauges, keyboards and touch screens.

The HSSL includes state-of-the-art glass-top touch-sensitive panels. These virtual controls are fully reconfigurable to duplicate control rooms of any operating nuclear reactor. The displays can reproduce hundreds of analog control boards, which real nuclear operator crews can interact with.

Design engineers observe these interactions and study human responses to normal and emergency situations in newly formatted control rooms. Such information can help enhance operator control and situational awareness.

The full-scale, 15-panel simulator was fully completed in March, though operator crews from HSSL's industry partners had begun running initial simulations with the technology in November.

"There is no other research facility in the world like this focused on control-room modernization," said Ron Boring, principal investigator for the Pilot Project on Control Room Modernization. "We're already developing prototypes that are demonstrating the benefits of new technologies at nuclear power plants. Modernizing these control rooms is hugely exciting research that also fills an important need in industry."

The HSSL is currently running three plant control models, with most development efforts focused on Shearon Harris Nuclear Plant in North Carolina, the first of many simulations for industry partner Duke Energy as the company begins digitizing its nuclear plants. The Electric Power Research Institute (EPRI) — which conducts research and development for the electric industry — is collaborating in HSSL's research.

"The HSSL provides the ability to rapidly develop prototype control-room modifications, get early feedback from control-room operators, and test new designs with realistic plant scenarios before the designs are built," said Joseph Naser, EPRI project manager and technical executive. "This will allow the designs to effectively and reliably meet the goals of the plant owner and will reduce the cost and time to implementation."

As the HSSL is used to gather data, the simulation results will be available for any company in the nuclear industry to use in control-room modernization, said Bruce Hallbert, an LWRS program manager.

The simulation lab team is currently working on prototype digital displays that would convey chemical balance, turbine control and other important plant information not captured on the current panels. The objective is to introduce information that can help human controllers maintain their situational awareness, particularly during emergencies.

"The goal of control room modernization is to replace aging analog technology," said Hallbert. "We want to enhance the functionality and safety of operating nuclear power plants by leveraging the capabilities of new digital technologies."

INL is one of the DOE's 10 multiprogram national laboratories. The laboratory performs work in each of DOE's strategic goal areas: energy, national security, science and environment. INL is the nation's leading center for nuclear energy research and development. Day-to-day management and operation of the laboratory is the responsibility of Battelle Energy Alliance.

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